ECM-989

ELECTRET CONDENSER MICROPHONE

SPECIFICATIONS

GENERAL

Type:	One-point stereo (employing the Mid-side capsules technique), electret condenser microphone (with back-electret condenser capsules)
FET:	Sony junction FET
Microphone Output Connector:	Cannon XLR-5-12C (the microphone unit and the control unit)
Battery:	Alkaline battery L40, SIZE AA (IEC designation LR6)
Dimensions:	ϕ40 x 275 mm (outside diameter x length) ($1\frac{5}{8}$ x $10\frac{7}{8}$)
Weight:	Approx. 320 g (10.5 oz)
Finish:	Metallic grey finish

PERFORMANCE

Frequency Response:	20 Hz – 20,000 Hz (See page 17)
Directivity:	Changeable (from 0° to 150°, See page 17)
Output impedance:	600 Ω ±20 % Microphone output connectors: balanced
Output Level (deviation ±3 dB):	Open circuit voltage*1 – 68.0 dB (0.4 mV) Effective output level*2 – 51.8 dBm *1 0 dB = 1V/1μ bar, 1,000 Hz *2 0 dBm = 1mW/10μ bar, 1,000 Hz Recommended load impedance is more than 3 kilohms.
Power Requirements:	Normal operating voltage: 1.5 V Minimum operating voltage: Approx. 1.1 V Current drain: Less than 30 mA (at normal operating voltage) Battery life: Approx. 30 hours with Sony alkaline battery AM3
Noise Level:	Signal-to-noise ratio: More than 46 dB (1,000 Hz, 1μ bar) Inherent noise: Less than 28 dB SPL Wind noise*1: Less than 45 dB SPL Induction noise from external magnetic field*2: Less than 5 dB SPL

*1 Wind noise is the value measured by applying a wind velocity of 2 m/sec. (6.6 ft/sec.) from all directions to the microphone. The mean value is taken and converted to the equivalent input sound level.
0 dB = 2 x 10^{-4} μ bar

*2 The external magnetic field induction noise is measured with the microphone placed in an alternating magnetic field of 50 Hz, 1 milligauss. The maximum noise value is taken and converted to the equivalent input sound level.
0 dB = 2 x 10^{-4} μ bar

Maximum Sound Pressure Input Level:	More than 130 dB SPL (at 1,000 Hz, 1 % distortion, 0 dB = 2 x 10^{-4} μ bar)
Dynamic Range:	More than 102 dB
Environmental Temperatures:	-20°C to +60°C (-4°F to +140°F) for storage 0°C to +60°C (+32°F to +140°F) for operation

SONY®

SERVICE MANUAL

1. CIRCUIT DESCRIPTION

MID SIDE (M.S) TYPE STEREO MICROPHONE

There are many methods for stereo sound reception. Of these, stereo reception of sound at a single point (that is, the "one-point" method) can use either a pair of microphones or the intensity method (the M.S method).

In the pair microphone method, the three elements of stereophony, namely, level difference, time difference, and phase difference are obtained by choosing appropriately the distance (expressed as phase difference) between the sound sources and the left and right microphones and the directionality of the microphones.

However, this method has the disadvantage that the position of the microphones for obtaining best stereophonic reception, as calculated for the phase difference, depends on the frequency of the sound especially when that sound is close to the pure tones such as from a flute.

At Sony, we have studied the second method, namely, the intensity method, which has a number of other merits apart from avoiding the above problem.

The intensity methods can be further divided into the M.S method and the XY method. Basically, in both the methods, the spacing between the two microphones is zero thereby resulting in zero time lag difference and zero phase difference and the stereophonic sound reception is achieved by merely the level difference in the outputs of the two microphones due to the difference in their directional characteristics. At Sony, we have selected the M.S method in which it is easy to change the angle of the main lobe axis of the microphone directional characteristics.

1. Principles of the Method

A stereo microphone using the M.S method consists two directional microphones placed physically close together in the same body. One of these is an unidirectional microphone while the other is a bidirectional microphone as shown in Fig. 1. The unidirectional microphone is placed in the microphone body with its main axis perpendicular to the axis of the bidirectional microphone.

The unidirectional microphone is called the "Mid" microphone because it receives the sound from the central region. The bidirectional microphone is called the "Side" microphone because it receives the sound coming from the sides. The name M.S method is derived from the first letters of these two words "Mid" and "Side".

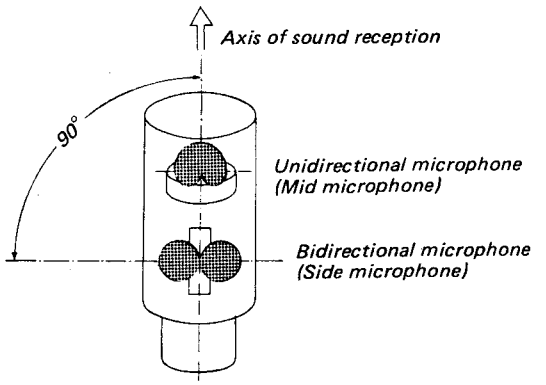

Fig. 1 The positions of the two microphones constituting an M.S stereo microphone

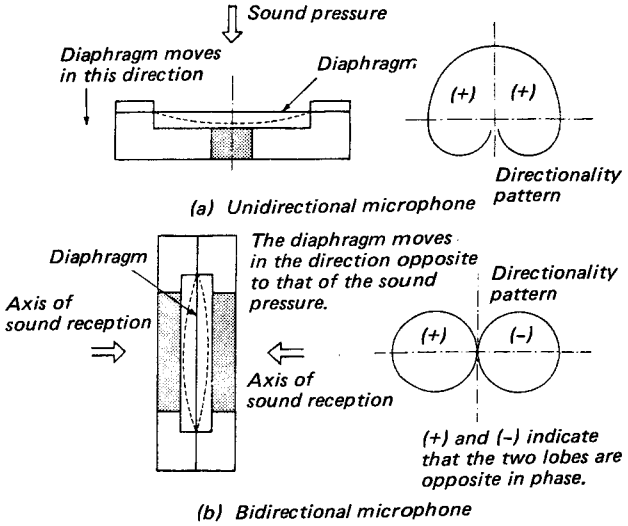

Fig. 2 The directional characteristics of the microphones and their phase relationship

The unidirectional microphone gives a positive phase output with respect to sound pressures from all directions because the forces moving the diaphragm are all in phase as shown in Fig. 2(a).

On the other hand the forces moving the diaphragm of the bidirectional microphone to the left and to the right will be opposite in phase and hence the outputs for the sound pressures from the right will be opposite in phase with respect to the sound signals from the left as shown in Fig. 2(b).

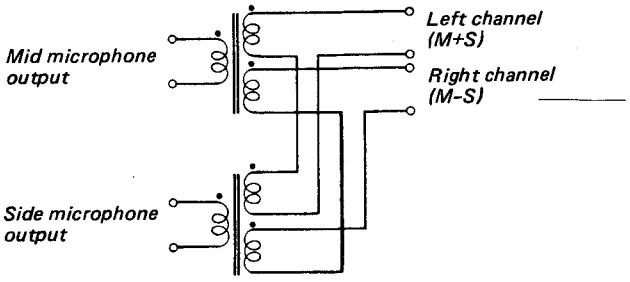

Fig. 3 The sum and difference circuit

ELECTRET CONDENSER MICROPHONE

ECM-989

E Model

No. 1
January, 1981

SUPPLEMENT

File this supplement with the service manual.

Please add the following parts in the list on page 17.

ACCESSORIES AND PACKING MATERIALS

Part No.	*Description*
1-528-052-00	Alkaline battery AM3
2-100-951-00	Adaptor, stand screw (SAD-34)
3-793-557-12	Leaflet

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SERVICE MANUAL

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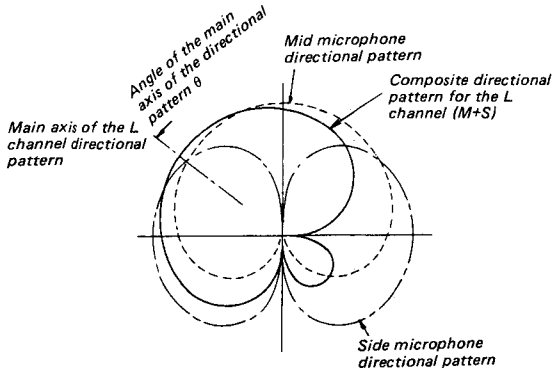

Angle of the main axis of the directional pattern θ
Mid microphone directional pattern
Composite directional pattern for the L channel (M+S)
Main axis of the L channel directional pattern
Side microphone directional pattern

Fig. 4 The left channel polar pattern derived by adding the mid and side microphone outputs (M+S)

The outputs from these directional microphones are input to a sum and difference circuit shown in Fig. 3 for generating the two channel stereo signals which are the sum (M+S) and the difference (M–S) of the outputs from the mid and side microphones. The sum signal M+S corresponds to the sound received from the left since the signals from the mid and side microphones will be in phase with each other when the sound source is at the left and out of phase when the sound source is at the right thereby yielding a composite polar pattern shown in Fig. 4.

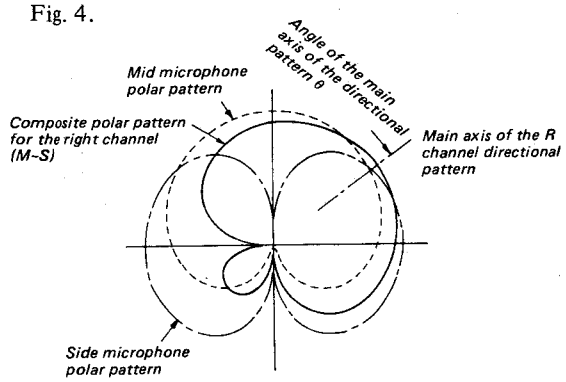

Angle of the main axis of the directional pattern θ
Mid microphone polar pattern
Composite polar pattern for the right channel (M–S)
Main axis of the R channel directional pattern
Side microphone polar pattern

Fig. 5 The polar pattern for the right channel signal obtained from the difference circuit (M–S)

The difference signal M–S has a directional pattern that is symmetrically opposite cardioid shape to the right instead of the left as shown in Fig. 5. This is due to the fact that the sign of the S component is reversed as compared to the M+S signal.
(See Fig. 5.)

In addition, if the sensitivity of the side microphone is decreased in relation to that of the mid microphone, it will be possible to change the angle of the main axes of these two cardioids. In other words, it will be possible to change the angle at which the L or R channel sensitivity is largest. In this manner, the M and S outputs are transformed into L and R outputs in this stereo microphone.

2. The Apparent Sound Source Orientation When the M.S Stereo Sound Reception is Used

The superiority of the M.S method of stereo sound reception is described here. First of all, the plot of the sound pressure difference (ΔP) versus the phase difference ($\Delta\phi$) of the sound signals arriving at the left and right ears of a listener is shown in Fig. 6(c) when a single sound source is placed at various angles from 90° left to 90° right of a listener. Corresponding to this the sound was recorded using a pair microphone and an M.S microphone with the position of the sound source varied at 30° intervals from position ① to position ⑦ . The sound so recorded are reproduced in a system using the speakers such as the one shown in Fig. 6(b). Now the reproduced sound can be considered to be closer to the natural sound if the plot of the sound pressure difference versus the phase difference is closer to plot mentioned earlier. The plot for the pair microphone is shown by the dot and dash line in Fig. 6(c). It is clear from this plot that a pair microphone has a directional response far different from what a listener would feel and hence does not reproduce the sound naturally. In contrast with this, an M.S stereo microphone has a directional response, indicated by a dashed line in Fig. 6(c), that is very close to that actually felt by a listener and also the orientation is proportional to the point of sound reception. This, in other words, means that the reproduced sound will be closer to natural sound.

3. Construction and Features of the Sony M.S Stereo Microphone

Sony has put on the market two new stereo microphones of the M.S type - ECM-989 and ECM-969. The ECM-989 is the highest quality stereo microphone in this series and has characteristics satisfying even professionals. Also, the capsule section and the control section of this microphone can be separated. The ECM-969 has a construction that does not permit the capsule section and the control section to be separated, but it has the same characteristics as the ECM-989. Both types of microphones are provided with a remote control switch which can be used along with a control box sold separately for remotely controlling the angle of the main lobe axes.

The features and the developmental history of the ECM-989 will be described below as it is representative of the microphones in this series.

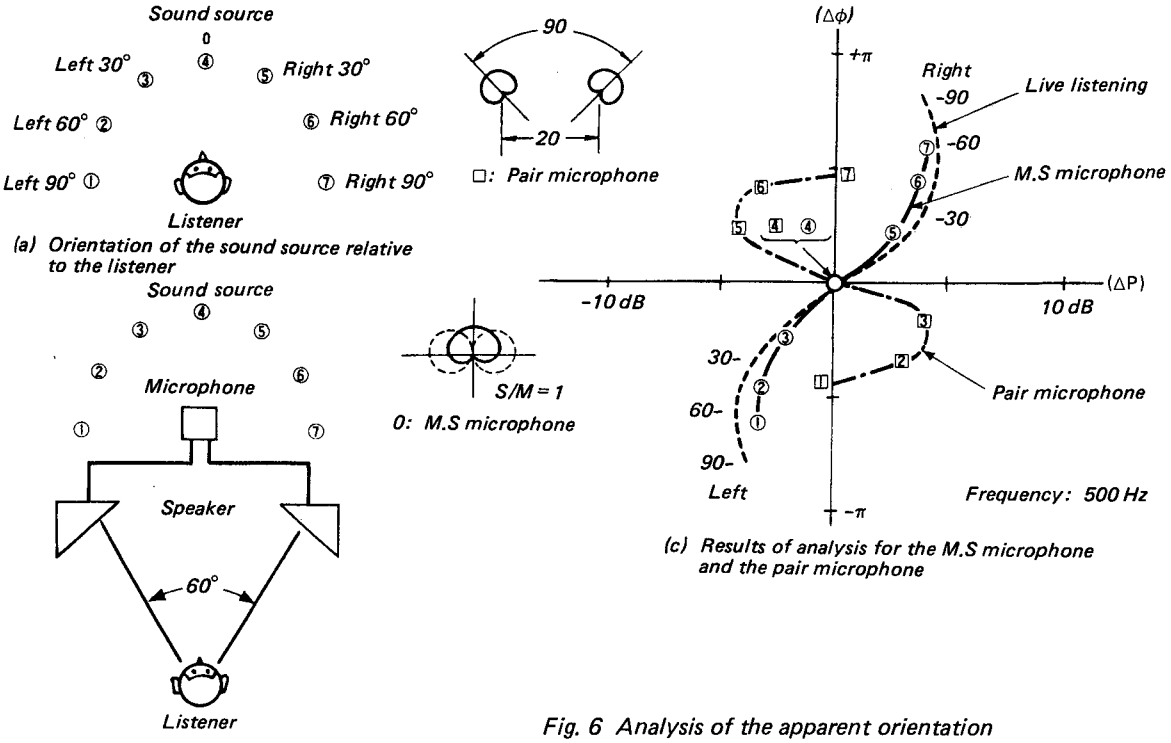


Fig. 6 Analysis of the apparent orientation of the sound source

4. Development of a Bidirectional Microphone

One of the main reasons for the hitherto expensiveness of the M.S stereo microphones is that it was difficult to manufacture unidirectional microphones and bidirectional microphones that have matching characteristics. As is also evident from the principles of the M.S stereo microphone, the frequency response of the bidirectional and unidirectional microphone should be identical, or else the apparent sound source orientation fluctuates depending on the frequency thereby defeating the purpose of using the M.S method. If the development of a general purpose microphone is being aimed at, it will be very difficult to place both a unidirectional and a bidirectional microphones with excellent characteristics in a limited space. In particular, it is even theoretically hard to get low frequency response from bidirectional microphone capsules and hence a long time was spent in developing this type of microphone.

The back electret condenser microphone used in the ECM-23F was selected for the unidirectional microphone which has the same excellent low frequency characteristics as a condenser microphone with DC bias on the diaphragm.

The use of this back electret microphone was considered for the bidirectional microphone as well because then it will be possible to obtain the same characteristics for the mid and side microphone thereby exploiting the features of the M.S method fully. Although the idea of building a bidirectional microphone using two unidirectional microphones was apparently simple, there were plethora of practical problems that had to be studied and solved such as noise, output level, and transmission conditions. Finally, a structure was arrived at after solving these problems one by one. This is the two-microphone differential amplifier structure. Using this method it was possible to obtain characteristics that were satisfactory in

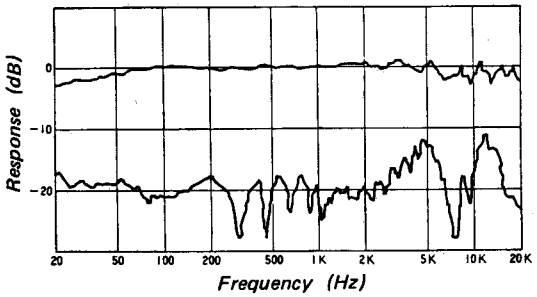


Fig. 7 The frequency response of the ECM-969

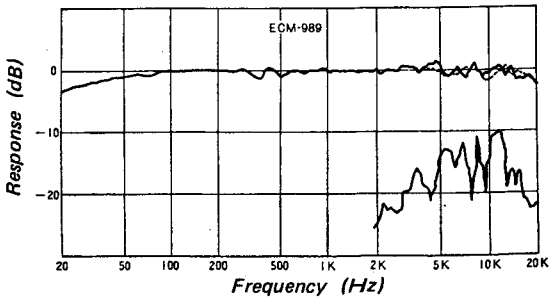


Fig. 8 The frequency response of the ECM-989

terms of the frequency response, output level, noise, and also in balanced coupling of transmission. The frequency response of the two types of microphones are shown in Figs. 7 and 8 respectively.

5. Achieving 100 m Separation Between the Capsule and Control Sections

The maximum separation permissible between the capsule and the control sections of the earliest versions of the ECM-989 was barely 30 meters. At that time we reascertained that a separation of at least 50 meters was being expected according to popular opinion. In view of this we started working on the development of a microphone that permitted a separation of at least a hundred meters between its capsule and control sections. In order to meet this requirement it is necessary that balanced coupling be used for both the channels M and S. One of the simplest methods considered for achieving this was the use of a sending and a receiving transformer shown in Fig. 9. But this method proved useless because it was hard to accommodate two transformers of sufficiently good characteristics in the limited space available and also the low frequency response was poor. The next method considered was the one using two differential amplifiers. Although this method resulted in excellent physical characteristics the number of transistors required became to much with consequent greatly reduced battery life, and hence this method was abandoned as impractical. This led us to the unconventional approach of providing the differential amplifiers in the capsule section and transformers in the control section shown in Fig. 10. In this scheme, however, the characteristics get limited by the transformers in the control section and hence these needed to be studied further.

In this attempt we succeeded in developing small size transformers that had very satisfactory low frequency response. Figure 11 compares the frequency response of the amplifier section when the capsule section and the control section are coupled directly with the frequency response when the two sections are separated by 100 meters. As is evident from this figure, the separation has hardly any effect at all on the frequency response. In addition, the power to the capsule section is supplied by

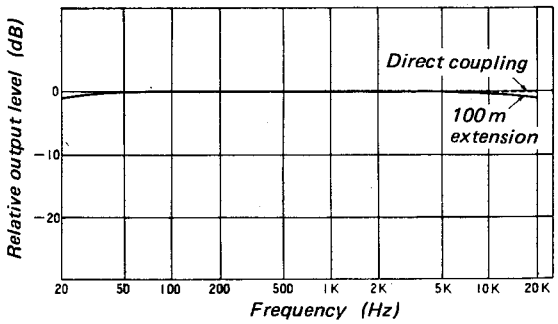


Fig. 11 The change in the frequency response due to a 100 m extension

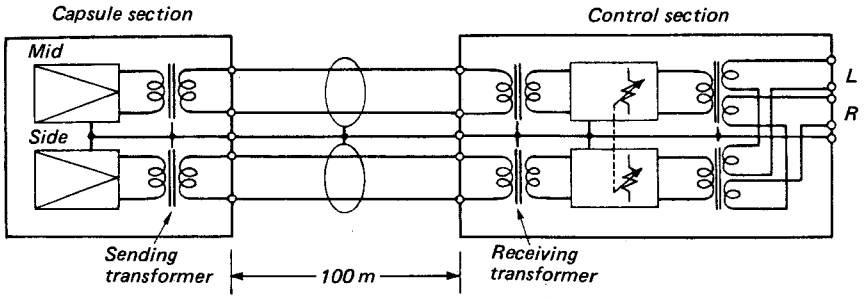


Fig. 9 Transformer - transformer coupling

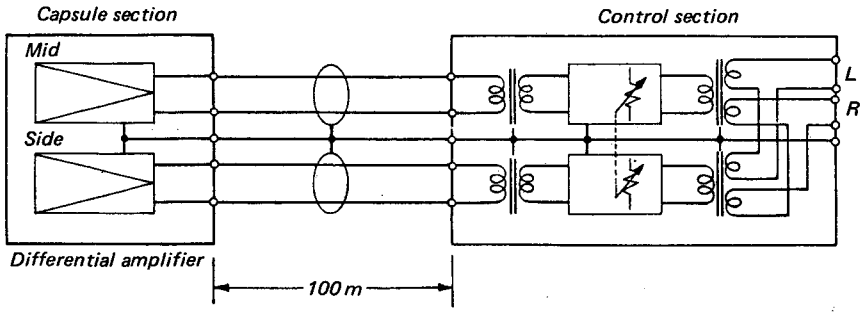


Fig. 10 Differential amplifier - transformer coupling

the Phantom powering method used commonly in the professional microphones. This balanced method of coupling makes it difficult for external noises to creep in and renders this microphone very useful with most of the usual extensions. The block diagram of the ECM-989 is shown in Fig. 12.

6. Variable Range of the Angle of the Main Lobe Axes

It was mentioned earlier that the angle of the main lobe axes of the M.S stereo microphone can be varied continuously with the theoretical range being 0° to 180°. In practice, however, the reverse phase components of the left and right channels becomes excessive at angles greater than about 150° which although giving the feeling of wideness makes the apparent sound source orientation unstable and also causes the reproduction to be unpleasant. Because of this reason the Sony M.S stereo microphones have been designed with a 0 to 150 degree range of variation of the angle of the main lobe axes with a click stop being provided at the most often used position of 120°. The variation is not linear over the entire range because the actual feeling of broadening, etc., with changes in the angle of the main lobe axes is least in the range 0° to 30° and maximum in the range 90° to 150°, thus requiring finer adjustments to be possible in the latter range.

7. Use of the Stereo Angle Remote Switch

The ECM-969 microphone has capsule and control sections that can not be separated but the angle of the main lobe axes can be controlled using a remote control function. In other words, the L and R outputs are given out when this switch is in the stereo position and the M and S outputs are given out otherwise.

Although a remote switch is not required in the ECM-989 because its capsule and control sections can be separated, it has been provided considering the use of the tone control function mentioned later. The remote control box performs not only the remote control of the angle of the main lobe axes but also acts as a tone control unit. This makes it very useful in outdoor recording applications. Because of these remote control switches all the Sony M.S stereo microphones can have their main lobe angles controlled remotely.

8. Efficient Use of M.S Stereo Microphones

For best stereo sound reception it is necessary to alter the angle of the main lobes depending on the conditions of the sound source, etc. The M.S stereo microphones are normally used in the "Mike off" setting. As a general guide, a 90° angle is used for recording the sound from a small band at a long distance from the microphone while a 120° or 150° angle is best for receiving the sound from a wide source such as a mixed chorus, etc.

Normally an angle of 120° (the click-stop position) is best for hand-held recording of natural sound or sound from moving sources. Unlike the conventional microphone, an M.S stereo microphone can receive sounds with no "dark region" in the middle, it will be possible to receive the sound from a quartet with a single microphone. Other applications include stereo recording of a discussion or meetings, etc., so as to improve the clarity of recording.

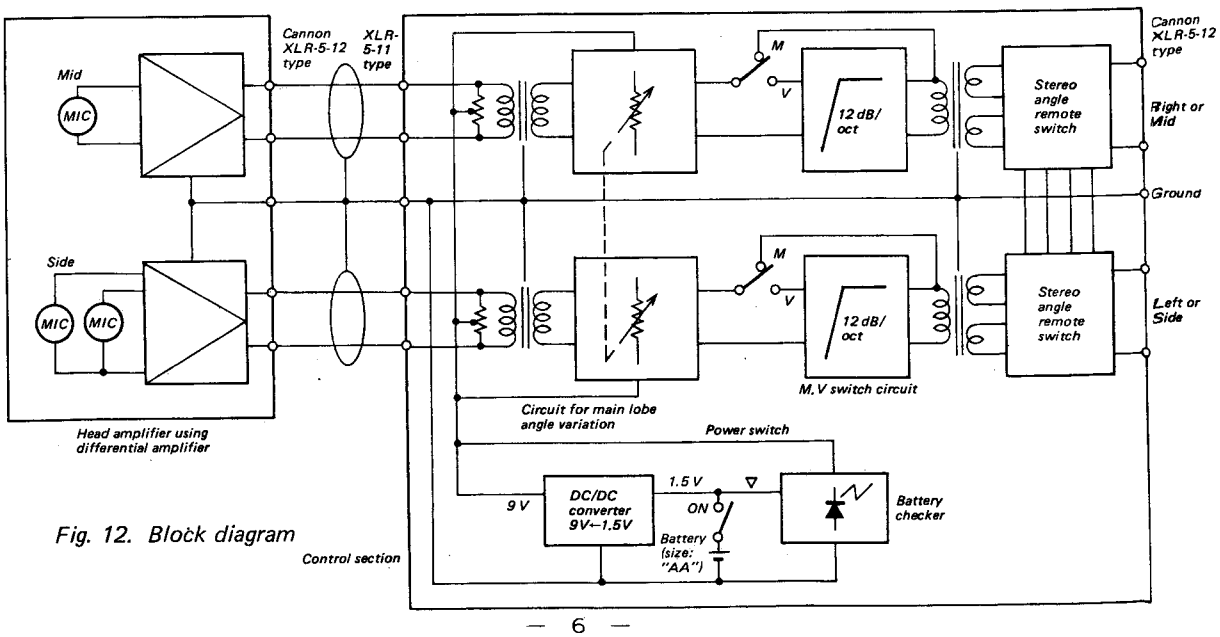
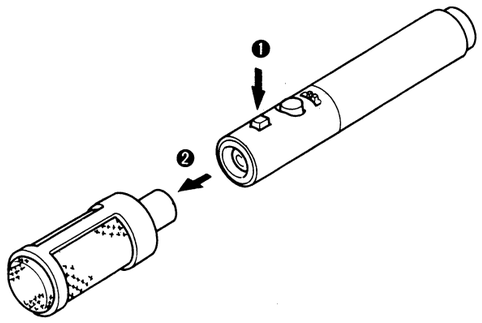


Fig. 12. Block diagram

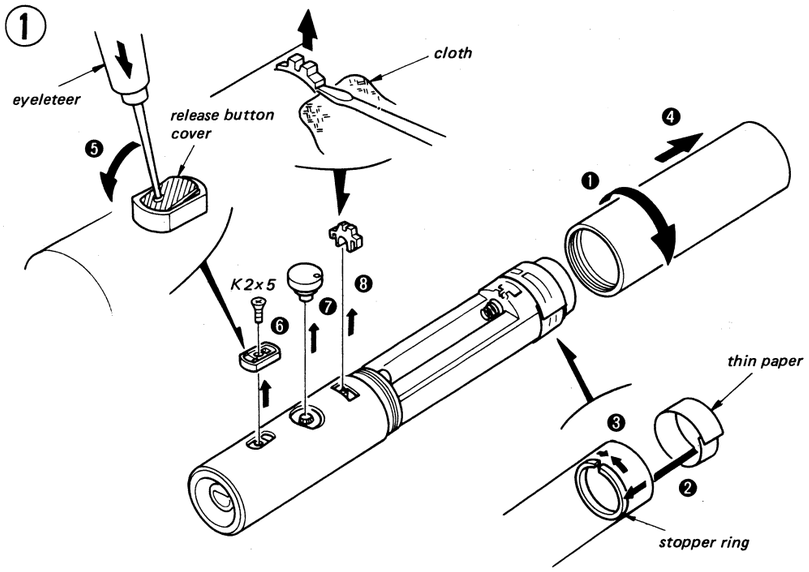
2. DISASSEMBLY

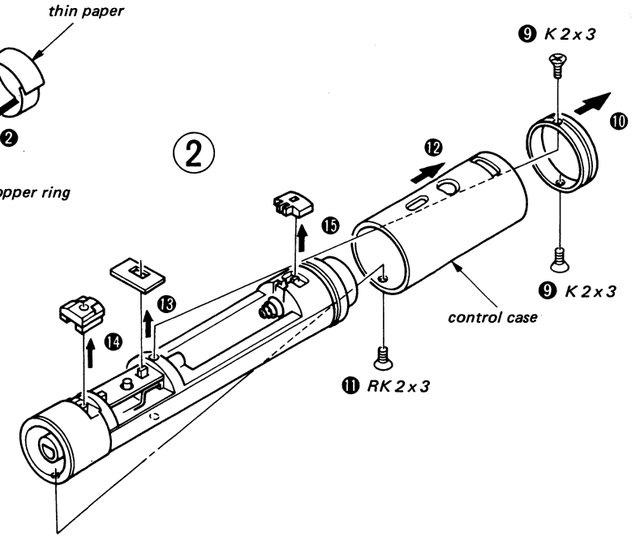
Note: Follow the disassembly procedure in the numerical order given.

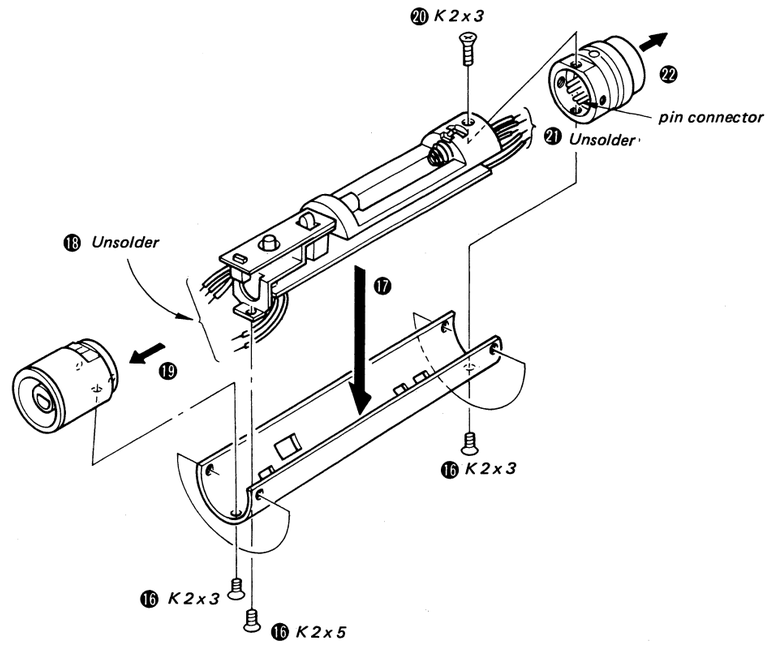
MICROPHONE CASE REMOVAL

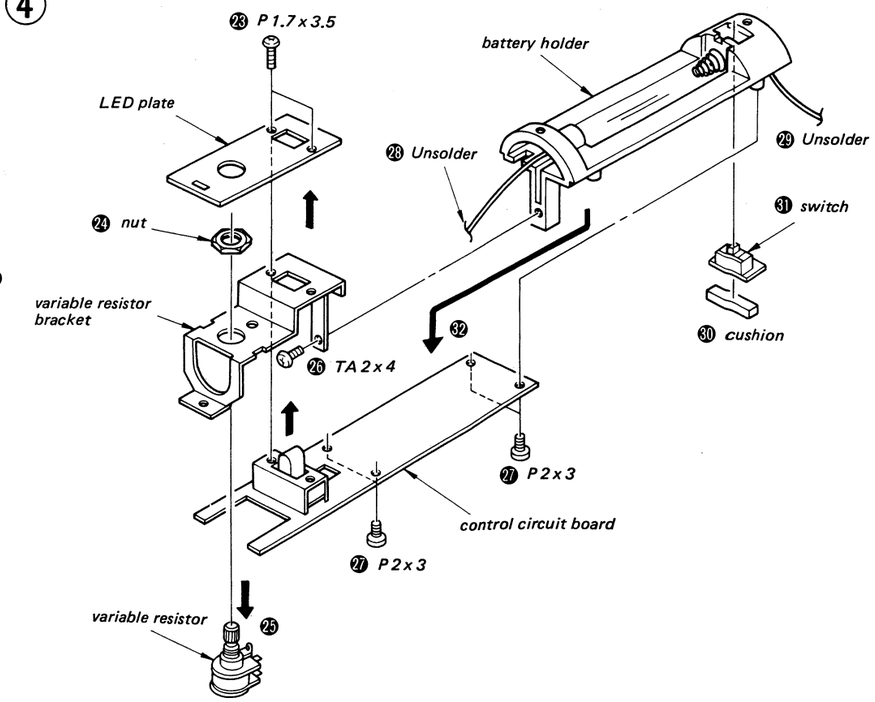


CONTROL CIRCUIT BOARD/SWITCH/VARIABLE RESISTOR/ CANNON PIN CONNECTOR REMOVAL



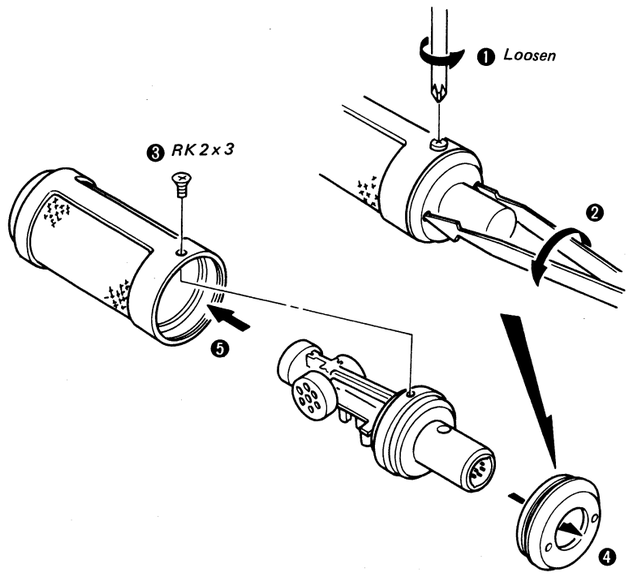






MICROPHONE UNIT/UNIT CIRCUIT BOARD/AMPLIFIER CIRCUIT BOARD REMOVAL

①



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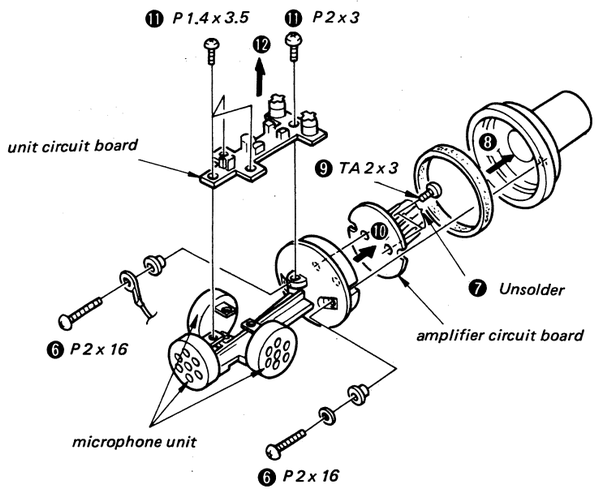
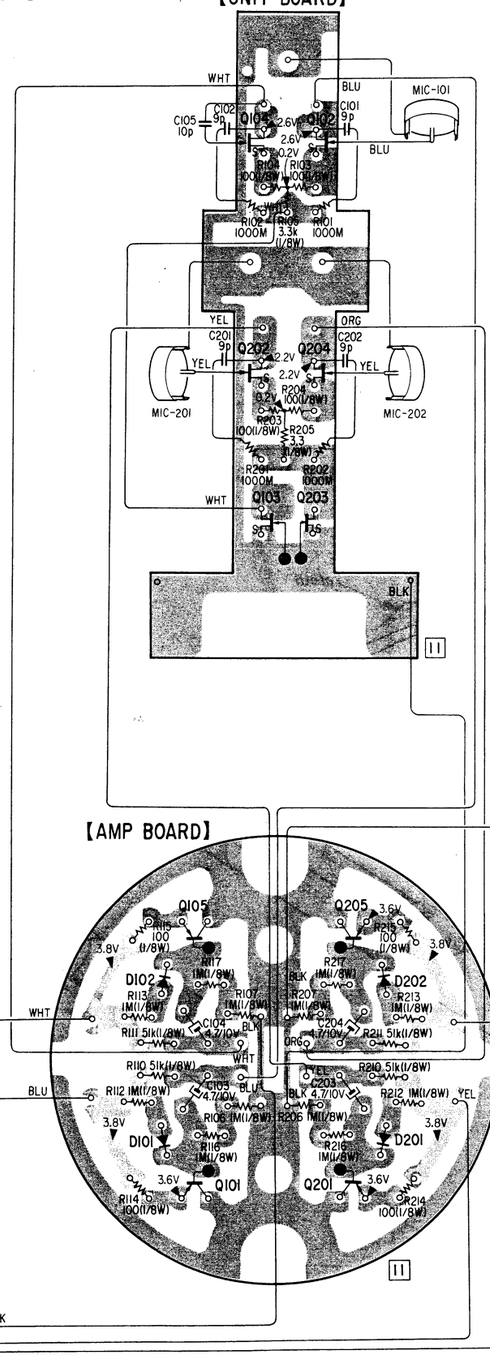


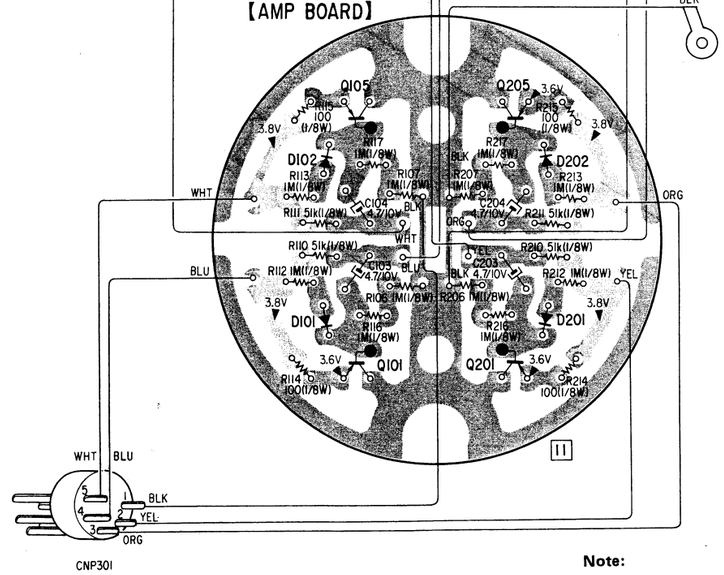
3. MOUNTING DIAGRAMS

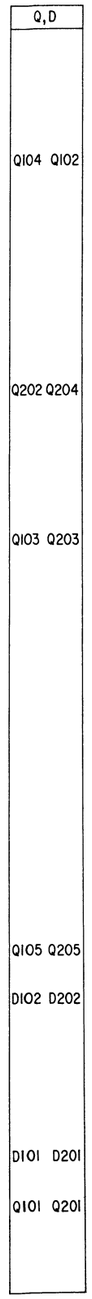
– Conductor Side –

【UNIT BOARD】



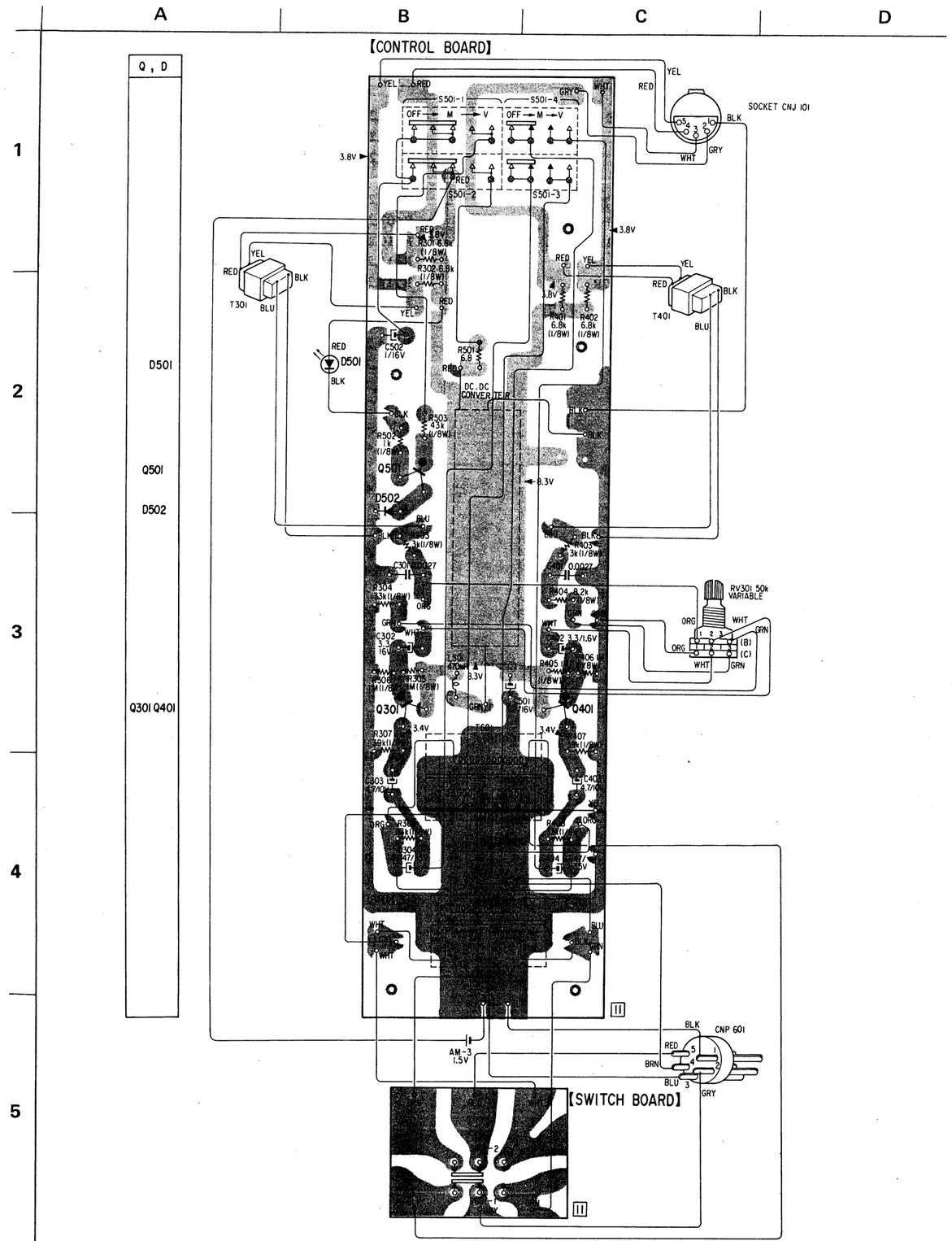
【AMP BOARD】



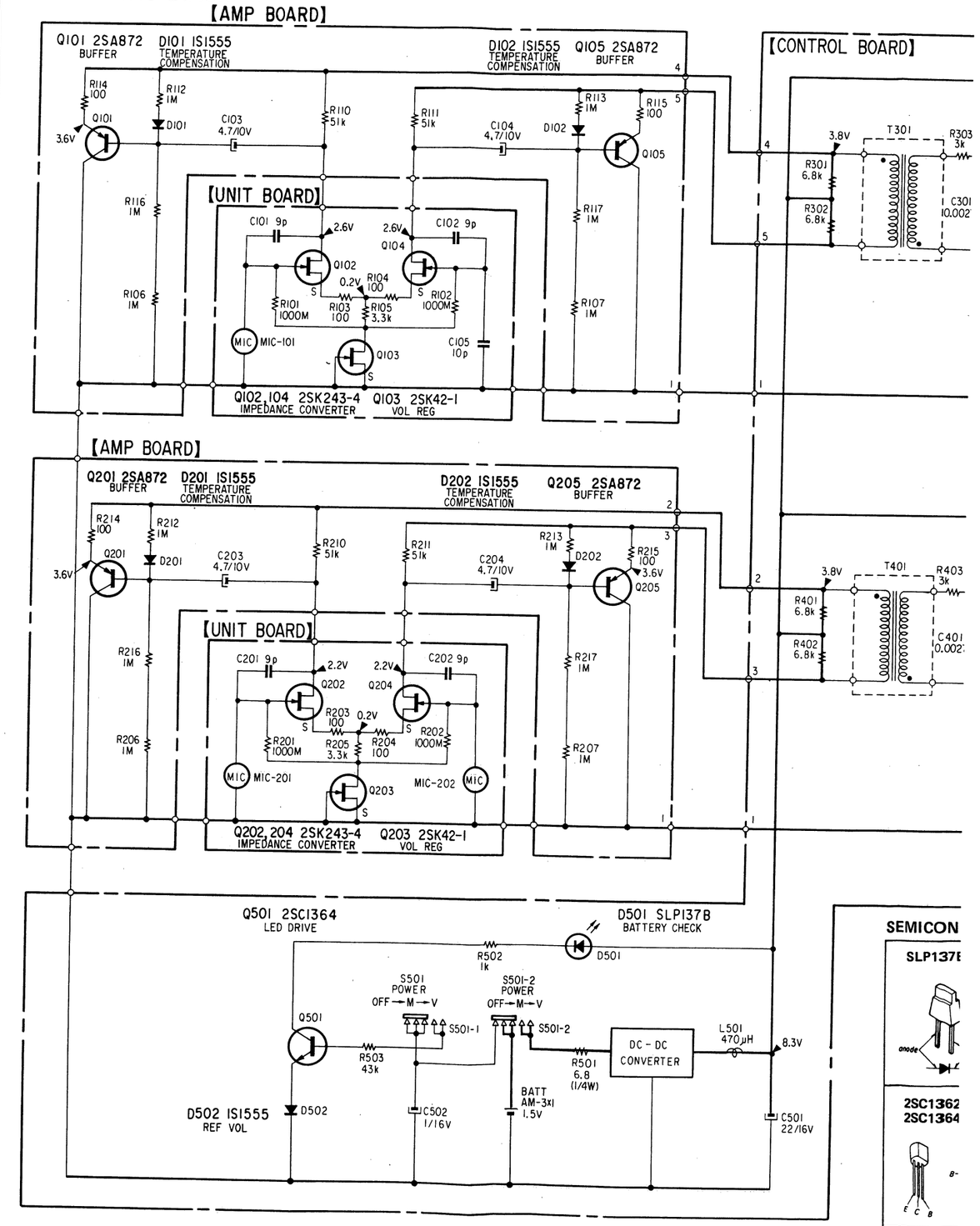


Note:

- ○— : parts extracted from the component side.
- ⊗ : Through hole.
- ▒ : B + pattern

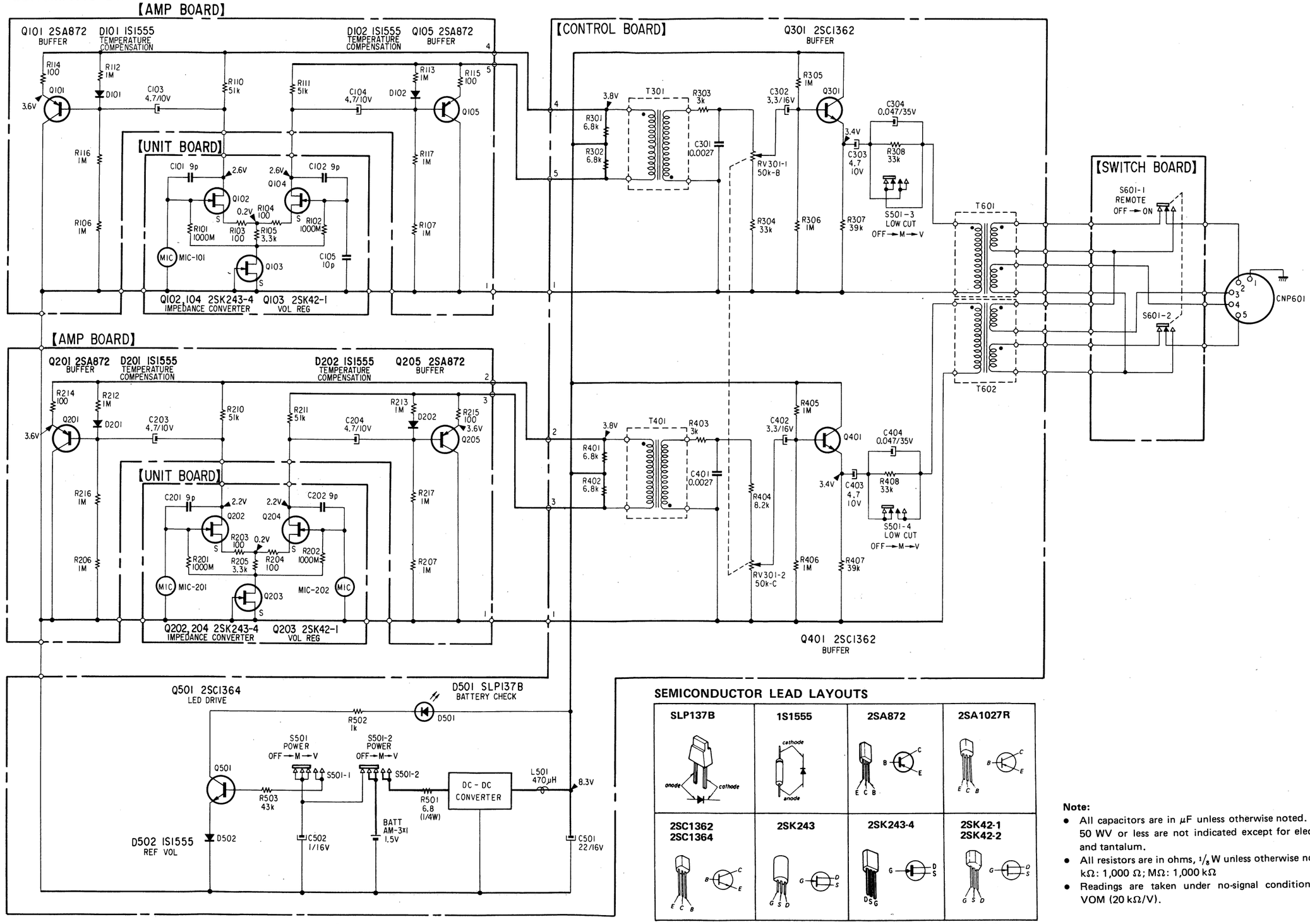


4. SCHEMATIC DIAGRAM



ECM-989

4. SCHEMATIC DIAGRAM



SEMICONDUCTOR LEAD LAYOUTS

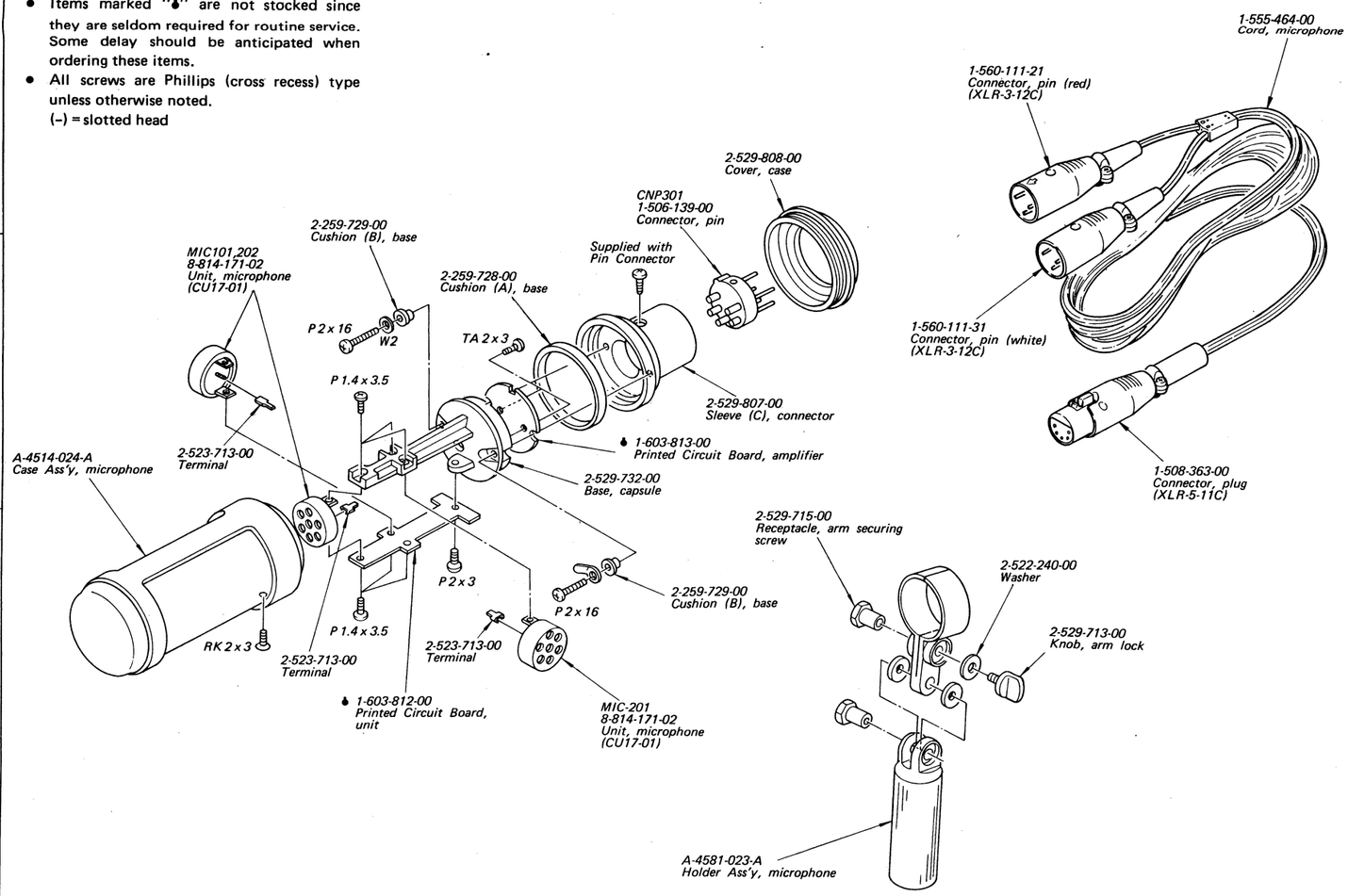
SLP137B	**1S1555**	**2SA872**	**2SA1027R**
2SC1362 2SC1364	**2SK243**	**2SK243-4**	**2SK42-1 2SK42-2**

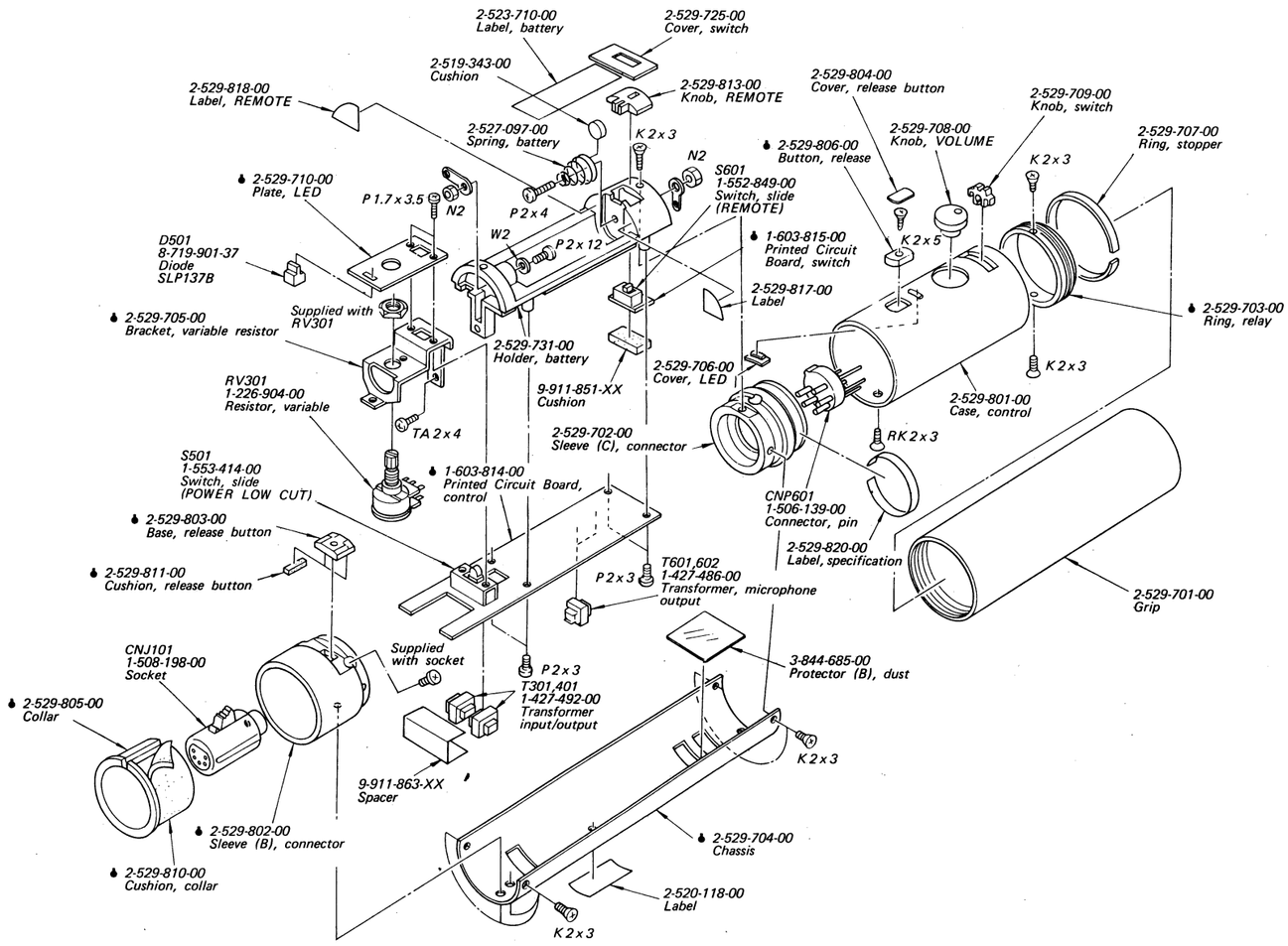
Note:

- All capacitors are in μF unless otherwise noted. p: μμF 50 WV or less are not indicated except for electrolytics and tantalum.
- All resistors are in ohms, 1/8 W unless otherwise noted. kΩ: 1,000 Ω; MΩ: 1,000 kΩ
- Readings are taken under no-signal conditions with a VOM (20 kΩ/V).

Note:

- Items marked "♦" are not stocked since they are seldom required for routine service. Some delay should be anticipated when ordering these items.
- All screws are Phillips (cross recess) type unless otherwise noted.
  (–) = slotted head





Ref. No.

Q101,2(
Q102,2(
Q103,2(
Q104,2(
Q105,2(

Q301,4(
Q501

D101,2(
D102,2(
D501
D502

C101,2(
C102,2(
C103,2(
C104,2(
C105

C301,4(
C302,4(
C303,4(
C304,4(

C501
C502

R101,2(
R102,2(

• Ite
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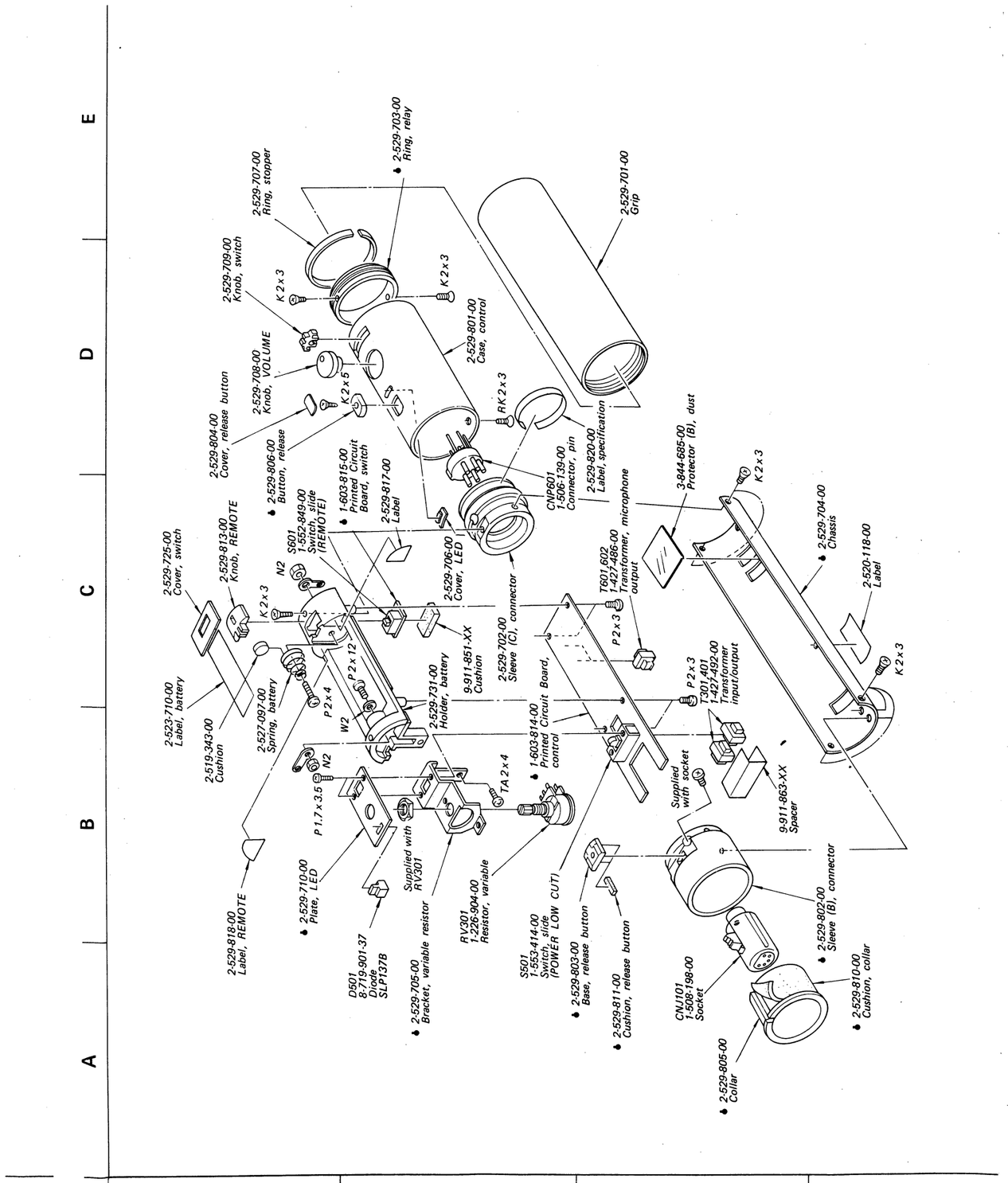


6. ELECTRICAL PARTS LIST

Ref. No.	Part No.	Description
	SEMICONDUCTORS	
	Transistors	
Q101,201	8-729-612-77	2SA1027R
Q102,202	8-765-654-00	2SK243
Q103,203	8-727-312-00	2SK42-2
Q104,204	8-765-654-00	2SK243
Q105,205	8-729-612-77	2SA1027R
Q301,401	8-729-665-47	2SC1362
Q501	8-729-663-47	2SC1364
	Diodes	
D101,201	8-719-815-55	1S1555
D102,202	8-719-815-55	1S1555
D501	8-719-901-37	SLP137B
D502	8-719-815-55	1S1555
	CAPACITORS	
	All capacitors are in μF. p: μμF, elect: electrolytic	
C101,201 C102,202	1-102-946-00	9 p 50 V ceramic
C103,203 C104,204	1-131-420-00	4.7 10 V tantalum
C105	1-102-947-00	10 p 50 V ceramic
C301,401	1-130-476-00	0.0027 50 V mylar
C302,402	1-131-368-00	3.3 16 V tantalum
C303,403	1-131-420-00	4.7 10 V tantalum
C304,404	1-131-479-00	0.047 35 V tantalum
C501	1-123-317-00	22 16 V elect
C502	1-131-347-00	1 16 V tantalum
	RESISTORS	
	All resistors are in ohms.	
R101,201 R102,202	1-208-256-00	1,000 M micro (with marking)

Ref. No.	Part No.	Description
R103,203 R104,204	1-210-355-00	100 1/8 W carbon
R105,205	1-204-123-00	3.3 k 1/8 W carbon
R106,206 R107,207	1-247-053-00	1 M 1/8 W carbon
R110,210 R111,211	1-246-864-00	51 k 1/8 W carbon
R112,212 R113,213	1-247-053-00	1 M 1/8 W carbon
R114,214 R115,215	1-246-771-00	100 1/8 W carbon
R116,216 R117,217	1-247-053-00	1 M 1/8 W carbon
R301,401 R302,402	1-214-577-00	6.8 k 1/8 W metal-oxide
R303,403	1-246-849-00	3 k 1/8 W carbon
R304	1-210-381-00	33 k 1/8 W carbon
R404	1-209-779-00	8.2 k 1/8 W composition
R305,405 R306,406	1-247-053-00	1 M 1/8 W carbon
R307,407	1-210-382-00	39 k 1/8 W carbon
R308,408	1-210-381-00	33 k 1/8 W carbon
R501	1-246-421-00	6.8 1/4W carbon
R502	1-204-122-00	1 k 1/8 W carbon
R503	1-246-863-00	43 k 1/8 W carbon
RV301	1-226-904-00	50 kΩ-B/C variable
	MISCELLANEOUS	
CNJ101	1-508-198-00	Socket
CNP301 CNP601	1-506-139-00	Connector, pin
MIC101 201,202	8-814-171-02	Microphone Unit CU17-01-02
L501	1-407-177-XX	Coil, microinductor 470 μH
S501	1-553-414-00	Swtich, slide; POWER, LOW CUT
S601	1-552-849-00	Switch, slide; REMOTE

• Items marked "•" are not stocked since they are seldom required for routine service. Some delay should be anticipated when ordering these items.

Ref. No.	*Part No.*	*Description*
T301,401	1-427-492-00	Transformer, input/output
T601,602	1-427-486-00	Transformer, microphone output
	1-464-134-00	DC-DC Converter

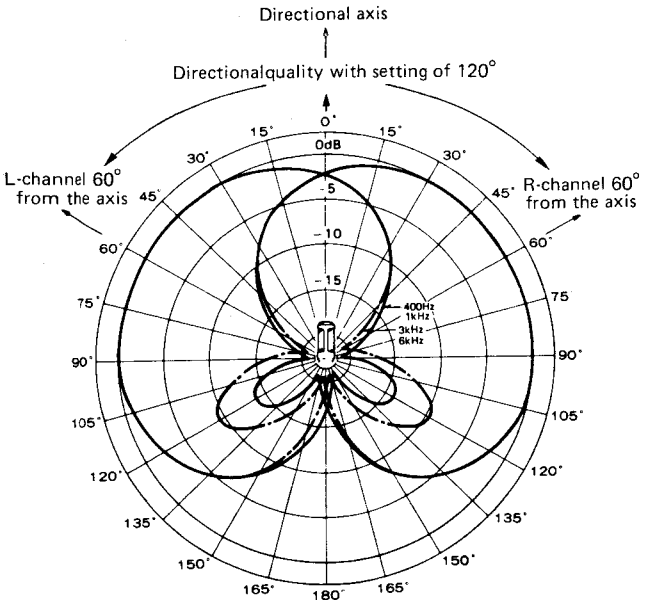
PRINTED CIRCUIT BOARDS

♦ 1-603-812-00	Unit
♦ 1-603-813-00	Amplifier
♦ 1-603-814-00	Control
♦ 1-603-815-00	Switch

ACCESSORIES AND PACKING MATERIALS

Part No.	*Description*
A-4580-007-A	Screen Ass'y, wind
A-4581-023-A	Holder Ass'y, microphone
1-508-363-00	Connector, plug (XLR-5-11C)
1-555-464-00	Cord, microphone
1-560-111-21	Connector, pin (XLR-3-12C)
1-560-111-31	Connector, pin (XLR-3-12C)
2-100-952-00	Adaptor, stand screw (SAD-35)
2-529-734-00	Spacer
2-529-809-00	Collar, holder
2-529-814-00	Carton
2-529-815-00	Case, carrying
2-599-154-11	Manual, instruction
3-701-630-00	Bag, plastic

FREQUENCY RESPONSE



DIRECTIVITY CHARACTERISTICS